



MINISTRY OF HEALTH

GATHERING GROUNDS

PUBLIC ACCESS
TO GATHERING GROUNDS

AFFORESTATION
& AGRICULTURE
ON GATHERING GROUNDS

REPORT OF THE
GATHERING GROUNDS SUB-COMMITTEE
OF THE
CENTRAL ADVISORY WATER COMMITTEE

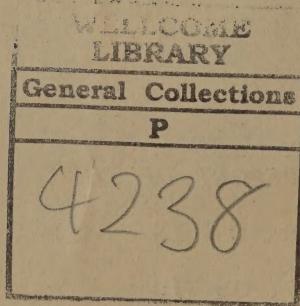
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Water Act, 1945

Adopted

Note. This Report has been prepared by the Gathering Grounds Sub-Committee of the Central Advisory Water Committee appointed by the Minister of Health under Section 2 of the Water Act, 1945. The Report was adopted unanimously by the main Committee.



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**CENTRAL ADVISORY WATER COMMITTEE
GATHERING GROUNDS SUB-COMMITTEE**

TERMS OF REFERENCE

To investigate the question whether the public should be allowed access to gathering grounds owned or controlled by water undertakers and the extent to which it is desirable that afforestation and agriculture should be permitted on gathering grounds.

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REPORT

TO THE

CENTRAL ADVISORY WATER COMMITTEE

GENTLEMEN,

1. We were requested to investigate the question whether the public should be allowed access to gathering grounds owned or controlled by water undertakers and the extent to which it is desirable that afforestation and agriculture should be permitted on gathering grounds. We have the honour to submit a report of our investigation of these questions.

Constitution

2. The original nine members of the Sub-Committee are all members of the main Committee, but power to co-opt was exercised in order to obtain the advantage of the special information possessed by Col. E. F. W. Mackenzie, O.B.E., M.C., M.B., D.P.H., Director of the Water Examination Department of the Metropolitan Water Board, Captain G. L. Bennett Evans, a substantial hill farmer, and Mr. L. K. Elmhirst, Vice-Chairman of the Footpaths and Access Sub-Committee of the National Parks Committee. We were also assisted during our deliberations by assessors from the Ministries of Health, Agriculture and Fisheries and Town and Country Planning and from the Forestry Commission. Mr. G. A. Worth, one of our original members found it necessary, owing to pressure of other committee work to resign from this Sub-Committee on the 7th March, 1947. Sir Robert Doncaster, who was only able to attend two of our meetings resigned from this Sub-Committee and from the main Committee on the 20th November, 1947.

Proceedings

3. We held our first meeting on the 12th July, 1946, and have subsequently met 11 times and heard 16 witnesses. In addition we have spent six days visiting gathering grounds and water-works; some 40 papers have been circulated to us, and a large number of other communications have been summarised for us by our Secretary.

4. Evidence of the present position in water gathering grounds has been received from the National Farmers' Union and from a number of organisations interested in public access. Evidence on behalf of the water undertakers concerned has been given by the British Waterworks Association and a number of individual undertakers. Finally we have been much assisted by evidence from other bodies and individuals and from certain water undertakers who do not own or control gathering grounds and are not therefore directly concerned in the subject matter of our investigation. A list of the bodies and individuals whose evidence we have had is contained in Appendix I.

5. The National Parks Committee set up by the Minister of Town and Country Planning has during part of the period of our activities been considering related problems, upon which it has now reported. Mr. L. K. Elmhirst is also a member of that Committee, and Vice-Chairman of its Footpaths and Access Sub-Committee whose Secretary, Sir Philip Magnus, has acted as one of our assessors.

Summary of Issues

6. It has been contended that the restrictions imposed by some water undertakers on agriculture and public access in the lands draining into their reservoirs are unnecessary and involve an undesirable interference with food production and healthy recreation ; the water undertakers concerned reply either that such restrictions are essential to the purity and wholesomeness of the water supply, or that they could only be relaxed if costly new purifying equipment were installed, and that it is unfair that the cost of this should be borne by the water-rate-payers. These arguments are, however, contested on the grounds that the present restrictions could be considerably relaxed without endangering purity or necessitating any more elaborate equipment than is desirable in any event. Both sides are agreed that the preservation of a pure and wholesome supply of water is essential and we have regarded this as axiomatic. The main question which we have had to decide, therefore, is whether any kinds of restriction at present in force could be so modified as to provide increased scope for food production and open air recreation without endangering the purity of water supplies.

Sources of Water

7. The problem we have to consider concerns gathering grounds " owned or controlled by water undertakers " ; we are thus limited to the consideration of certain types of water supply. Water undertakers in this country obtain their supplies from several different kinds of source ; some obtain it by way of deep wells or boreholes of varying depths tapping underground water-bearing strata ; some use shallow wells or natural springs ; some pump water from substantial rivers ; some collect surface-water in impounding reservoirs by damming small rivers running through populous agricultural country. Finally, many towns situated near relatively unpopulated hills have obtained a wholesome and copious supply of surface water by damming hill streams and forming reservoirs in wild and remote upland country ; the same system has been followed by certain large towns situated at a considerable distance from the hills and a number of these have had to construct large and costly aqueducts in order to obtain a supply which was not available to them locally. It is chiefly among the users of these upland sources that undertakers who own or control their gathering grounds are to be found.

8. In general the type of source used by a town or district is governed by its geographical situation in relation to the availability of water ; it is natural that the nearest satisfactory source, whether underground, river, upland, or lowland should be used. There is sometimes, however, an element of doubt as to the suitability of an available source, and the threatened exhaustion of underground supplies, or the increasing pollution of a river has on some occasions obliged a large undertaker to develop a distant source of a different kind. For example, Birmingham Corporation, who originally drew their supplies by pumping from the local river Tame were driven by its increasing pollution to develop a costly system of reservoirs in central Wales, and Coventry Corporation, whose present supplies are mainly from underground sources are now building an aqueduct from the River Severn to meet the town's increasing consumption.

Purity

9. In the nineteenth century the expansion of industry and population increased the dangers of polluted drinking water, while the parallel advance in medical science and civil engineering shed fresh light on the means by which such dangers could be avoided. Many of the expanding industrial towns were conveniently situated near available upland water supplies, and, as the Pennines

became ever more thickly dotted with reservoirs, it came to be widely appreciated that the water obtained from these practically depopulated moorlands was of a high natural purity. In more recent times the seclusion of the upland gathering grounds has been affected from two directions. In the first place improved means of transport and a growing desire for open air recreation have led increasing numbers of townsmen to invade the hills in search of health and pleasure ; in the second place the pressing need to increase home food production is giving rise to a tendency to cultivate many tracts of marginal land which were formerly considered unsuitable. The first tentative invasions of their privacy were met by many water undertakers by measures to prevent public access and farming. Now, however, the invasion has grown in strength and become vocal. Ramblers and hill farmers both demand to be treated as legitimate representatives of important trends in the nation's life, and their differences with some water undertakers now call for solution on broad grounds of national advantage. It is to this problem that we consider our terms of reference to be directed.

Croydon Epidemic

10. The fatal epidemic of typhoid at Croydon in 1937-38, and the legal proceedings which followed it, drew renewed public attention to the dangers of polluted water and led all concerned with water supply to review the adequacy of their own safety arrangements. The polluted water which was found to be the cause of that disaster was not derived from an upland source, and was held to have been contaminated in a well and not in a gathering ground, but the alarm which it caused, and the magnitude of the compensation which had to be paid, persuaded a number of undertakers with upland sources to tighten up their own arrangements. In a memorandum issued by the Ministry of Health,* shortly after the epidemic, general advice for the protection of water supplies of all kinds was given, and it was urged that upland undertakers "should, wherever reasonably practicable, acquire the whole of the gathering ground above the reservoir, dam or intake, and protect the reservoir or intake by adequate fencing"; the memorandum continued "Steps should be taken to secure that drainage from farmyards or houses remaining on the gathering ground, or the manuring of land on the gathering ground does not pollute the source of supply. The conversion of a polluted and therefore dangerous water into a safe potable water is a matter requiring the greatest care if the health of the consumer is not to be jeopardised. There is often a tendency to think that, provided arrangements are made for chlorination, safety is secured, whatever the condition of the raw water. It cannot be sufficiently stressed that a policy of reliance on a single line of defence between the consumer and a polluted source of water supply is fraught with danger".

11. Many undertakers have in the past 50 years spent large sums on the acquisition of extensive tracts of gathering grounds ; some have attempted not merely to control, but entirely to prevent, public access and agriculture on their moorlands. The area occupied by controlled gathering grounds bears a very small proportion to the total area of the country, but it cannot, merely on that account, be treated as insignificant. A map submitted to us in evidence,† shows, for example, that, of the area proposed for the Peak District National Park, roughly a third, comprising some of the finest mountain scenery, is covered by an uninterrupted mosaic of gathering grounds. These are not all owned by water undertakers, but the fact that they are gathering grounds would have to be taken into consideration in deciding any questions of public policy regarding access to them.

* Memorandum on the safeguards to be adopted in day to day Administration of Water Undertakings. Ministry of Health Memo. 221, issued January, 1939.

† By the Joint Committee for the Peak District National Park.

12. Before discussing the extent to which control of gathering grounds is necessary in the public interest, it is expedient to consider in some detail the object of such control, and the precise means by which that object may be achieved.

Waterborne Diseases

13. The main object of restrictions imposed by water undertakers, as such, upon agriculture and public access, is the prevention of waterborne diseases. By far the most important of them at the present time is typhoid, or enteric fever, and most of the measures taken to ensure pure water are directed to the prevention of this disease, but gastro-enteritis also is frequently waterborne and paratyphoid more rarely. Other bacterial complaints which can be waterborne, include dysentery and Weil's disease ; simple diarrhoea may be caused by excessive amounts of putrescent organic matter in water.

14. A waterborne disease of greater fatality is cholera, but, happily, it no longer presents a serious practical problem in this country. Epidemics in London in 1832, 1849, 1854 and 1866 did much to direct public attention to the need for proper administration of water supplies, but the consequent reforms proved effective, and since 1866 there has been no outbreak in Great Britain. The last epidemic in neighbouring countries is believed to have been at Hamburg in 1892. The development of long distance air travel may, however, give rise to renewed anxiety ; the period of incubation of cholera is such that an infected person coming from the East by sea would invariably reveal the disease before arrival in this country, but if he travelled by air this might not be so.

15. Measures which are taken against the spread of waterborne infection may be broadly divided into—

- (a) protection of the source,
- (b) purification between the source and the distribution system, and
- (c) protection of the distribution system.

Protection of the source, to be effective, entails not merely general measures to exclude known causes of contamination, but also regular analyses of the raw water and careful investigation to identify and eliminate the cause of any actual pollution revealed. Purification of surface water involves the largely mechanical process of filtration through sand, followed by chemical sterilisation, usually by means of chlorine, the whole process being tested and regulated by further bacteriological analyses. Measures to prevent the water becoming polluted in the course of distribution do not involve any question coming within our terms of reference.

16. The germ which gives rise to typhoid fever has its natural home in the human bowel ; it does not occur in the bowels or excreta of animals. It is found in the bowels of people who are actually suffering from the disease, and may remain there for a very long time after recovery. It also occasionally occurs in the bowels of people who have received the infection without actually contracting the disease at all. It is expelled with the faeces or urine and may continue to live for some weeks outside. If while still alive it finds its way into the bowels of another person, that person is likely to contract the disease. One of the ways by which the germ has frequently been transferred from one person to another is by traces of the excreta of a sufferer or carrier getting into a drinking water system, and it is to prevent this that most of the measures for the protection and purification of water are directed.

17. Water treatment systems in some cases include processes for the removal of certain minerals whose presence in water in sufficient concentration may be harmful to health or unpalatable, but such processes can be ignored for the purpose of our investigation.

18. The Memorandum referred to in paragraph 10 above mentions 21 outbreaks of waterborne disease between 1911 and 1937 which had been conveyed by public water supplies and were of such gravity as to merit detailed mention in the annual reports of the Chief Medical Officer of the Ministry of Health. In 14 of the cases referred to, the disease was enteric or typhoid fever, in two, paratyphoid fever, in two bacillary dysentery and in four gastro-enteritis; cases of enteric fever attributable to the water supply followed immediately upon two of the gastro-enteritis outbreaks. In 13 of the 21 outbreaks there was reason to suppose that the water had become polluted at the source, and of these, nine were derived from underground sources and the remaining four from surface sources. Brief particulars of the latter are as follows:—

- (i) At Kenilworth in December, 1913, there were 43 cases of typhoid. In November sewage from a house where a typhoid patient was being nursed had drained into a stream which obtained access to an adit from which the water supply was drawn.
- (ii) At Bedlington in the winter of 1917-18 there occurred a prolonged series of 141 cases of typhoid. A severe frost followed by thaw had affected the sand filter used for the treatment of a water supply drawn from a river.
- (iii) At Ogmore and Garw in the summer of 1922 there was an outbreak of dysentery with 1,100 cases. During alteration to the waterworks a temporary supply was obtained from a mountain stream which was unprotected throughout its course. A road ran alongside and paths crossed it, and human and animal excreta were found near it; children played in and near it. The specific source of contamination was not definitely determined but it was thought that excreta from some infected person must have been deposited near the brook and washed into it by rain.
- (vi) At Denby Dale, Yorkshire, between September and December, 1932, there were 75 cases of typhoid with 11 deaths. During September a typhoid patient was being nursed in a house whose water-closet drained into a small water-course which communicated with a small reservoir (2,400,000 gallons) about a quarter of a mile away. There was no purification.

19. The results which have attended the general adoption of measures to secure a pure water supply are exemplified in the following figures showing the annual death rate from typhoid fever, per million of population from 1871 to 1944.

1871-1880 (average)	320	1937	5
1881-1890 (average)	200	1938	4
1891-1900 (average)	170	1939	3
1901-1910 (average)	90	1940	3
1911-1920 (average)	35	1941	4
1921-1930 (average)	11	1942	2
1934	4	1943	2
1935	4	1944	1
1936	6		

20. Since no major waterborne disease can be conveyed in drinking water unless traces of the excreta of an infected person have got into the system, it follows in theory that if the gathering ground were so protected as to preserve the water from all human contact from the time it fell on the ground as rain until its arrival in the tap, the spread of these diseases by water would be

entirely eliminated without any need for purification. Some undertakers have attempted to approach this ideal as closely as possible, but we know of no case where the possibility of contamination has been wholly excluded. Many remote gathering grounds are crossed by roads or railways and even where this is not the case no system designed to exclude human access is likely in this country to be completely enforced in practice. Even if it were possible, as it seldom is, to exclude from the reservoir and gathering ground all human beings other than medically examined employees, the possibility would remain of pollution at second hand by sea-gulls. These birds, which are protected by law, frequently develop the habit of spending their days feeding on sewage farms and migrating at night to some convenient stretch of clear water, often enough a reservoir, each with human sewage on its feet and in its gullet. The water industry is at present engaged in research into scientific or other means of preventing pollution by seagulls, but no satisfactory remedy has yet been developed.

21. Though complete protection of the source is thus impracticable and though in most gathering grounds the actual practice comes nowhere near complete protection, we regard it as significant that no case has been mentioned in this country where disease has been transmitted by the pollution of a large reservoir, even where no effective filtration or sterilisation has been provided. This fortunate result is due to many factors of which an important one must be the purifying effect of storage. It has been stated above that the natural home of the typhoid germ is the human bowel, and although it can survive for a time in water, it will not do so indefinitely. Its eventual destruction is occasioned partly by generally unfavourable conditions of life and partly by the hostile action of other more vigorous organisms whose natural home is in fresh water; this dual action is exemplified by the fact that typhoid germs survive longer in sterile water than in ordinary raw water. It is estimated that, generally speaking, typhoid germs will not survive more than a month in a reservoir. If therefore the reservoir is of such a size in relation to the draw-off that all water is normally stored for longer than that, it can be assumed that any germs entering it will normally die before they leave. This is not, however, an infallible rule, for even if the average period of storage were double that regarded as lethal to germs, there are no means of preventing individual departures from the average, and a quantity of infected water might well be carried across a reservoir by a current and reach the outlet in a much shorter time. Nevertheless, we are not aware of infection having been spread in this manner in this country, and storage in a large reservoir is normally regarded as an important element in the process of purification. A few water systems, even today, rely almost entirely on protection and storage and do not include fully effective treatment; the balance of opinion, however, is not satisfied to leave the matter there.

22. The great majority of supplies drawn from upland gathering grounds, and all satisfactory supplies derived from rivers or populous lowland gathering grounds, are purified by filtration and sterilisation. Filtration is primarily intended to remove suspended solids from the water, and may be effected by slow sand filters, rapid mechanical filters, or a combination of both. In slow sand filtration the water passes through a bed of fine sand; a biological film forms naturally on the surface and in the interstices of the sand and tends to destroy any living organisms passing it. In rapid filtration the water passes through a bed of coarser sand which may be used merely as a mechanical strainer to be followed by slow sand filtration. Rapid filtration, may, however, be used alone, in which case it is usual to add a coagulant to the water which, by forming a gelatinous deposit on the sand, performs a similar function to the natural film of the slow sand filter. If the filters are properly tended and water is passed through at the correct rate, very few germs will survive filtration. Those that do are dealt with chemically by sterilisation, usually with chlorine,

but sometimes with ozone. It is important to realize that the proper function of chlorination (or other sterilisation) in the treatment of surface water is as one step in a series. Used alone it is not satisfactory. Surface water which has not been filtered usually contains much suspended and organic matter which is likely to absorb the chlorine intended for the destruction of micro-organisms. Also, particles of matter of a relatively substantial size may contain many germs embedded in their interior which will not be reached during the process of chlorination but will be carried on alive into supply. In emergency these effects can sometimes be overcome by greatly increasing the dose of chlorine, but this gives the water a characteristic unpleasant taste and would never be acceptable as a normal practice. Even in dealing with filtered water, the more efficient undertakings make constant analyses and vary the chlorine dose from time to time, and in some cases from day to day, to meet the varying constitution of the water. Chlorination alone, therefore, cannot be considered a reliable safeguard in the case of surface water, except possibly in certain particularly favourable conditions.

23. As has been indicated, bacteriological analysis plays an essential part in the provision of pure water. The routine tests carried out by water undertakers, however, are not designed to reveal the typhoid germ but are directly concerned with another micro-organism, the *Bacterium coli*. There are two reasons for this. First the presence of the typhoid germ is difficult to detect, though research is in progress with the aim of finding a simple test for it. Second, and more important, the *Bacterium coli* is a normally harmless organism present in all healthy bowels and its great value as a danger signal is that its presence in water reveals, before any actual contamination with disease germs has taken place, that excreta are getting into the water. It is thus usually possible to trace and remedy a means by which infected excreta might get into the water before an infected person has in fact begun to pollute the supply. It has been suggested to us in evidence that too much attention is paid by water undertakers to this normally harmless organism. We hope we have made it clear that such is not the case, and that to wait for the appearance in water of actual disease germs before taking action would be to lock the stable door after the horse had gone.

24. The weakness of *Bacterium coli* as a warning agent is that it is not confined to humans but is emitted in the faeces of all warm-blooded animals. It is mainly for this reason that steps are taken to avoid traces of animal excreta getting into water supplies. If the water is normally maintained free from *Bacterium coli*, any new human pollution will at once become apparent, but if the water were regularly polluted by animals, additional human pollution might go unnoticed and the effectiveness of the protective measures could not be adequately tested. Attempts have been made to devise some new test whereby human sewage could be differentiated from that of animals, but so far these have been without success. If such a test were practicable the main objection to pollution by animals would disappear. We are glad to know that research into a practicable method of differentiation is continuing as we consider this to be a matter of importance. Heavy pollution by animals is however subject to the further objection that it may complicate the process of chlorination. Such pollution is apt to vary in extent from day to day and, since chlorine is used up in oxydising harmless organic matter as well as in eliminating disease germs, any variation in the state of the water calls for an adjustment of the chlorine dose; hence the chlorination of a variable water requires more attention and provides more opportunity for error. It is important to bear in mind this distinction between animal and human pollution, viz. that human pollution is a direct danger to health but animal pollution can only endanger health indirectly by putting difficulties in the way of the defensive system. The practical effect of the distinction is that animal pollution can be dealt with empirically in each

water system by seeing that it does not reach such a magnitude as to be a serious practical difficulty, whereas all risk of substantial human pollution must be guarded against without waiting for trouble to arise.

25. It has been suggested that a "pure and wholesome" water must not only be palatable and free from actual danger to health, but must also be kept free from anything which an ignorant person might suspect of being unhealthy or an imaginative and squeamish person might consider objectionable. We agree, of course, that public confidence must be maintained and that, for instance, it is probably wise to draw attention to the importance of pure water by keeping the buildings and equipment at a water-works in a state of neatness and polish beyond what is of direct practical utility, but this policy must not be carried too far. We consider that it is going too far if land is totally withheld from productive use on the grounds that the occasional presence of a defecating cow or dead sheep in the feeder streams, while no actual danger to health, is "not a nice idea". The same imaginative objection could, we suppose, be taken to the presence of fish droppings and dead fish in the reservoir itself, but no one has proposed to us that reservoirs ought to be kept free of fish. It is probable that many persons concerned have not appreciated the vital distinction between human and animal pollution, and we therefore think it advisable to put on record the following extracts from the evidence given on behalf of the Society of Medical Officers of Health by Sir William Savage, M.D., D.Sc. with which we are in full agreement:

"Farming activities involve animals grazing and dropping their dejecta, and the manuring of fields. In other words animal excreta will get on the land. The pathogenic organisms which are waterborne do not affect animals so such animal excreta is not a means of spreading them."

"The comparative unimportance of animal manurial contamination has been discussed. These animal pollutions are however a serious nuisance in connection with laboratory control."

Present Practice

26. We have received evidence from 24 typical upland undertakers and their answers to our questions have varied widely, both in the opinions expressed regarding the risks from public access and agriculture, and in their statements regarding the actual conditions imposed in their own gathering grounds. Their replies on certain important points are summarised in Appendix II.

27. As to their practices, a few have bought the whole of the land draining into their reservoir, some have bought the greater part of it, some a small part surrounding the reservoir, and some none at all beyond what was required to construct the reservoir. Some have made bye-laws governing conduct in the gathering grounds and some have obtained special statutory Zones of Protection within which development is restricted. Of those who have power to do so, some endeavour, with varying success, to prevent all human access except by their own staff, some exclude the general public but allow sporting tenants and licensed fishermen, some issue conditional licences on payment of a fee, some try to confine the public to recognised paths, some try to preserve the banks of the reservoirs, some allow restricted boating and some attempt no control at all. Some do not attempt direct control but consciously rely on the control exercised by landowners on the gathering ground for the purpose of preserving game. As regards agriculture, one or two undertakers have demolished farm-houses and try to exclude all animals, including sheep. Most allow or encourage sheep, but many prohibit cattle and cultivation, either entirely or within varying distances of the reservoir. A few make no attempt to prohibit any kind of farming but make arrangements for the safe disposal of farm sewage. Finally a few take no steps in relation to farming at all.

28. Opinions expressed vary as widely as practices. On the subject of public access Mr. J. Shepherd, M.I.C.E., A.M.I.Mech.E., Water Engineer to Burnley Corporation said :

" Except in cases when public footpaths have been preserved under the provisions of Local Acts, public access to gathering grounds has always been prohibited and this is undoubtedly the best policy from the Undertakers' point of view, and affords the greatest safety to consumers. In the opinion of the Burnley Council restriction on public access is essential."

Mr. Alan Atkinson, M.Eng., M.I.C.E., M.I.W.E., Water Engineer to Manchester Corporation likewise said :

" For various reasons a limited degree of access must be tolerated, but the risk of pollution becomes progressively less the more we approach the ideal of total exclusion. Undertakers therefore consider that they are only doing their plain duty in applying the greatest degree of restriction upon access of the public to their gathering grounds which their local circumstances will permit."

Mr. Noel Wood, M.C., M.I.C.E., the General Manager and Engineer of the Sheffield Corporation Waterworks, however, said this :

" Whatever pollution may enter the reservoirs due to the presence on the gathering grounds of small parties of pedestrians is not regarded as serious in view of :

- (a) the normal purifying effect of storage in large reservoirs,
- (b) the filtration by slow sand or pressure filters,
- (c) sterilisation,

which all Sheffield water receives. Such pollution is infinitesimal compared with the pollution that many undertakings drawing supplies from large rivers have to face."

And Mr. A. M. Paterson, M.I.C.E., Engineer of the Bristol Waterworks Company* said :

" Access to gathering grounds under proper control of such matters as rest centres, fire precautions, etc., should not be discouraged. I should regard it as very unlikely that the quality of the raw water would suffer to any appreciable degree or that in general any extension of measures of purification over those now existing would be necessitated by such access."*

29. On the subject of agriculture, Mr. Robert Wyllie, A.M.I.C.E., Engineer and Manager to the Irwell Valley Water Board said :

" All farming activities should be prohibited. Cattle must not be permitted, and whilst sheep are not as objectionable, there is definite pollution from dead sheep."

But the Derwent Valley Water Board said :

" It is considered that cattle should not be allowed to graze along the water's edge, but that no restrictions are necessary with regard to sheep. Ploughing, fertilization or other farming activities may be permitted, but the drainage from farm premises is liable to cause gross pollution of streams and requires special provision and constant attention."

30. Comparison of the nature and position of gathering grounds where different policies are in force makes it evident that the differences are partly due to circumstances, but by no means wholly so. There is no hard and fast division between upland and lowland gathering grounds and the modern

* Note that the Bristol supplies do not come from typical upland gathering grounds but from the impounding of small streams on agricultural land in the Mendip Hills.

tendency to resume hill farming is blurring the distinction still further. In a definitely lowland gathering ground, such as those of the Leicester Corporation, agriculture was usually fully developed before the construction of the water works, and the purchase of the whole catchment for the purpose of putting an end to farming was obviously out of the question. In the typical upland gathering ground situated in a remote moorland, where at the time when powers were first obtained there was practically no human activity, purchase of the whole catchment was not too expensive, and was frequently carried out, though more often with the aim of preventing new development than of putting an end to any existing use of the land. In a number of mixed cases the area was mainly wild but contained a few farms, and the primary purpose of purchasing the land was usually, not to stop farming, but to exercise control over its methods by means of clauses in the farmers' leases. There is accordingly a considerable correspondence between the original state of a gathering ground and the regime in force in it today; undertakers who acquired uninhabited land frequently prefer to keep it so, while those who established their works in more populous country are mostly satisfied with their ability to produce a pure water without drastic interference with existing land use. And where farming already exists on any significant scale, public access is seldom regarded as dangerous.

31. There are, however, many differences of policy which cannot be accounted for by circumstances and can only be ascribed to genuine differences of opinion about the magnitude of the risks involved. For example Plymouth and Torquay both draw their water from remote parts of Dartmoor, but Plymouth Corporation do not object to public access, except within the reservoir fence, and only restrict agriculture in the immediate vicinity, while Torquay Corporation are opposed to public access and the keeping of cows anywhere within the catchment. Again Manchester and Sheffield both own similar extensive gathering grounds within a short distance of each other in the Peak District, but Sheffield Corporation adopt a markedly more liberal attitude towards ramblers. An example of an undertaking dissatisfied with the status quo is Swansea Corporation, one of whose upland gathering grounds contains several small farms; the Corporation have no powers of control at present but Mr. T. Price, M.I.C.E., M.I.W.E., their water engineer, expressed himself strongly in favour of acquiring control in order to put an end to farming. At the other extreme are the council of a small town who at the time of our visit were quite content to exercise no supervision at all over public access, hotels or farms on the shores of the small upland lakes from which their unfiltered supply is drawn.

32. The war brought changes in many gathering grounds. Much land which had not been farmed since the establishment of waterworks was ploughed up, and the presence of troops under training in many catchments provided an experiment in large scale human access. Anxiety was felt about both these developments. Compulsory ploughing was made subject to the approval of the Minister of Health, which was only given after careful consideration of each site and with limitations concerning extent and position; we have heard no complaints of ill effects from the many cases where ploughing was introduced. Likewise, although we have been given instances of insanitary behaviour on the part of the troops, this has been accompanied in only one case by evidence of any observed effect upon the quality of the raw water.

Principles of Gathering Ground Control

33. In the face of this diversity of practice and opinion is it possible to lay down a uniform policy to be followed generally in upland gathering grounds? It has been suggested to us by the British Waterworks Association that this should not be attempted, that the variations in policy are due to differing

circumstances, and that each undertaker's opinion of what precautions are necessary should be regarded as sacrosanct. For reasons set out above we cannot accept the view that all variations in policy are due to local circumstances ; we have had the clearest indications that widely different views are held by different undertakers on the principles involved. While, therefore, we do not consider it desirable that a universal code of practice should be laid down in detail, we do think it probable that useful conclusions of a general nature can be drawn, and that if these were to be widely accepted by undertakers and applied to their varying local conditions, the present differences in practice, while not wholly removed, would be greatly reduced.

34. A number of witnesses have rightly drawn attention to the fact that water purity rests upon several lines of defence, any one of which may be subject to temporary failure. In a typical case :

the first line will be the efforts to eliminate potential sources of pollution of the raw water, these, as we have shown, can never be wholly reliable ;
the second line is long storage ; this is a defence that seldom fails in practice but is subject to uncontrollable variations ;
the third line is filtration ; and
the fourth chlorination (or sterilization by ozone or other means).

These two last lines are both subject to human error on the part of the expert staff engaged on their management ; cases have been recorded in this country of infected water passing through temporarily defective filters or by-passing filters or chlorination plant and causing disease ; chlorination, as we have explained above, is a process requiring skilled attention. Since, therefore, no single line of defence is infallible, it is the course of wisdom to employ a series, in the faith that the odds against them all failing at the same time are so great as to amount almost to certainty.

35. While it is, in our opinion, indisputable that more than one line of defence is required, the question remains, how many ? Since we are dealing with probabilities it must be admitted that every additional line reduces, in theory, the chance of infection, but if the piling on of additional defences becomes burdensome, the process must eventually be brought to a stop. It is a commonplace of history and of natural history that over-developed defences may stifle the life they are designed to protect, and it would not be in the national interest, if, dissatisfied with effective practical security against typhoid, the water industry were to pursue theoretical perfection in this one field of public health at the cost of seriously limiting facilities for healthy exercise and the production of wholesome food. We must, therefore, consider to what extent extreme precautions against pollution do in fact interfere with desirable activities, and to what extent such interference in fact adds to the security of the water supply.

Extent of Restrictions on Access

36. The Report of the National Parks Committee* has drawn attention to the fact that wild and beautiful country is, in England and Wales, of limited extent and in need of preservation. Every attempt to remove any of it from the reach of people who appreciate it must therefore receive critical attention. Even though in some parts of the country, such as Dartmoor or the Welsh Hills, the gathering grounds at present used for water supply form only a few small patches in a large stretch of beautiful land, and visitors, most of whom have already travelled some distance, could take their recreation in the next valley, it is undesirable that they should be needlessly impeded. In other regions,

* Cmd. 7121. Presented by the Minister of Town and Country Planning, July, 1947.

however, notably the Peak and Central Pennines, the gathering grounds cover a substantial part, if not the whole, of the natural open air playgrounds of adjacent industrial towns, and to exclude the public from them would often be in practice to deprive the local inhabitants almost entirely of good walking country within reach of home. Many people in other parts of the kingdom have, of course, no dales or moorland within easy reach but the character of many of the northern industrial towns renders their local moorlands of particular importance for recreation. It must be borne in mind, moreover, that the demand for water per head of population is increasing rapidly and that the exploitation of additional gathering grounds will therefore undoubtedly be required in the future.

37. In most of the cases, of which we have received evidence, where there is a general prohibition of access, certain roads and pathways have remained open because the undertakers have been unable lawfully to close them. Cases have been mentioned to us, however, in which attempts have been made to extinguish ancient rights of way across the hills. In other cases, while the roads have remained open, use of them by ramblers and others has been discouraged by closing inns and farm houses where food and accommodation had formerly been obtainable. Some undertakers have dedicated and marked new footpaths on unobjectionable routes over their gathering grounds and endeavoured to confine public access to these. This is a policy which in some cases has overcome criticism and led to a good deal of co-operation between undertakers and local hiking clubs. Many young people from towns who like to hike in groups appear to prefer a well-beaten track, or even a motor road, but other more individualist ramblers like to get well away and resent any attempt to confine them to paths. Owing to the nature of the case it appears in practice to be impossible to confine walkers to defined paths over wide stretches of wild hill-land, but even if those who stray away are only occasionally spoken to by wardens the mere attempt to interfere with an apparently blameless activity must be a source of ill will and tend to reduce respect for more important restrictions. Representations have also been made to us against restrictions on camping and caravanning in gathering grounds, and the prohibition of boating in reservoirs; on these points we shall have more to say later.

38. Before leaving the complaints by advocates of access we feel we should deal with one persistent suggestion which has been made, namely that an important motive of water undertakers in seeking to exclude the public from gathering grounds has been the preservation of game. We are satisfied that this suggestion is misleading, and that in all the cases of restricted access of which we have any knowledge the motive has been a genuine, if sometimes possibly exaggerated, fear of pollution. It may well be that where undertakers have taken the view that access by a few people is harmless but that a crowd would be dangerous, a practical way of enforcing their policy has been to let the shooting rights, or leave the land in the hands of original proprietors who used it for that purpose, and rely on game-keepers to keep out the general public.

39. In a number of Local Acts of Parliament authorising the establishment of upland gathering grounds, clauses have been included specifically preserving public rights of access. Two of the most interesting are the Birmingham Corporation Water Act, 1892, which authorised the great Elan Valley reservoirs in Central Wales, and the Manchester Corporation Water Act, 1878, authorising the use of Thirlmere as a source of water. The relevant clauses from the former Act, often referred to as the Birmingham Clauses, are set out in Appendix III.

Extent of Restrictions on Agriculture

40. Appendix II indicates the extent to which certain agricultural practices are restricted or prohibited by the undertakers whose evidence we have received. Although, in a few cases, previously existing farms have actually been closed

down, the more usual course taken has been to regulate the types of fertilizers, and the types and numbers of animals on existing farms and prevent the further extension of agriculture and until recently the over-all effect upon agricultural production has perhaps been slight. The lands where farming was regulated or prohibited were not lands where it would have been of any great importance at the time. The weight of the present controversy depends almost entirely on the modern tendency to extend agriculture into difficult land where it was previously not worth while.

41. During the war it became necessary to produce much more food at home because our customary supplies from abroad were being interfered with by German submarines. The submarines have been defeated but the necessity still exists today and appears likely to become permanent, because our altered position in the world makes it no longer financially possible to buy the bulk of our food overseas. It has therefore become the declared policy of the government to extend home food production in every possible way, and conditions are being created which will make it worth while to farm land that before the war would not have been thought good enough. At the same time, improved methods are making the farming of hill land more productive. With the use of modern machinery and methods, many of the lower hill lands could be ploughed and reseeded, with a great increase in their productivity. The higher hills in which many of the gathering grounds occur, could carry full stocks of sheep; and the quality of the grazing would not only be prevented from deteriorating but would be greatly improved by increased stocking with cattle, which keep down the coarser grasses and trample down the young bracken and thus check its spread. In our visits to certain gathering grounds we noticed that bracken was rampant where cattle were not allowed. The keeping of cattle and sheep on the hills was fostered during the war by special subsidies for whose continuance provision is made in the Hill Farming Act, 1946. It is important not only in itself but also because of the part played by the hardy foundation stock from the hills in the structure of the livestock industry as a whole. Restrictions on the use of hill farms may, however, be such as to make the farming of them uneconomical and lead to their abandonment. For example, if a farmer is restricted to keeping sheep, it may destroy the whole economic basis of his farming enterprise. We are advised that wherever possible cattle should be kept as well, and that this is particularly important to farmers at the present time owing to their grave losses of sheep as a result of the recent abnormal winter. A number of undertakers who gave evidence took particular exception to pigs but we know of no scientific basis for such an attitude, apart from the conditions in which they are sometimes, but need not necessarily be, kept.

42. So far as arable cultivations are concerned, restrictions are often quite properly imposed on the use of certain of the grosser organic manures on fields near the reservoir or containing feeder streams. The restrictions imposed by some undertakers on the use of artificial fertilizers is a different matter. If, as is the usual practice, the land is ploughed across the slope, there should be little danger over a period of substantial quantities of soil and fertilizers being washed into the reservoir. It is contended by some undertakers that the use of fertilizers causes mechanical difficulties in the filters in that they encourage the growth of algae in the reservoir. Evidence by the Freshwater Biological Association supports the view that any fertilizer which favours the growth of crops will also, when washed into the reservoir, favour the growth of algae. The extent of consequent inconvenience varies from one undertaking to another, a factor of importance being apparently the depth at which water is drawn off into supply. There can be no doubt that lowland undertakers have to contend with a water which for this reason and others is less clear, and therefore more trouble to purify, than upland water, or that they succeed in doing so. It is

doubtful, however, whether the amount of additional cultivation that would be possible, if permitted, in upland gathering grounds would have sufficient effect upon the quality of the water to render existing treatment plant inadequate and we do not consider that this possibility could, in existing circumstances, justify the permanent withdrawal of land from food production.

Effectiveness of Defences

43. There can be no doubt, in our opinion, that the policies pursued by a number of water undertakers today do have undesirable effects in the spheres both of access and of agriculture and that they can therefore only be justified if it can be shown that nothing less would be sufficiently effective.

44. We accept the principle that a domestic water supply requires more than one line of defence of its purity. Many large river undertakings have only two lines of any reliability, filtration and sterilization. There is normally some effort to check the grosser forms of pollution of the river, but a polluted source is frankly accepted. That such systems have in fact, in this country, usually managed to produce a reliable supply reflects great credit on their technical staffs who have had, we know, many anxious times. Systems using an habitually polluted source without long storage are commoner in America than in this country, and so are waterborne diseases. Evidence from the United States indicates that epidemics of waterborne disease in places where the water system relied entirely on treatment have been relatively common, even, it is said, where the purification measures have been thoroughly up to date and theoretically adequate. Experience in this country has been more fortunate but the high standard of reliability attained in the recent past should not lull us into forgetting how much of it is due to the personal skill and reliability of a comparatively small number of men, the numbers or reliability of whom may not always be as adequate as they are today. We would not, therefore, encourage reliance upon purification alone.

45. A very few upland undertakers still have no thorough purification and place their faith in long storage plus simple sterilization without filtration, backed up in most cases by attempts to protect the source. Such systems rely substantially on storage and it is to this no doubt that their freedom from trouble is primarily due.

46. We visited a large lake which is one of the principal sources of water supply of a County Borough. The gathering ground draining into the lake contains much forest, a few sheep, and no farms, arable land or cattle. Public access, however, is guaranteed by statute and there are motor roads along both sides of the lake used extensively by motor coaches and other traffic. Notice-boards are placed at short intervals along these roads warning the public that the lake is a water supply and urging them to refrain from polluting it or from leaving the road. The water drawn from the lake is passed into supply without any filtration, though since the war it has been chlorinated. The representatives of the Corporation who spoke to us expressed the strongest hostility to public access and fear of the consequences of any increase, and quoted numerous cases of misbehaviour. At the same time they did not welcome the suggestion that their water might be filtered. Their attitude to both matters as expressed in their evidence was that the Corporation had gone many miles for pure water which, owing to its excellent quality, did not need to be filtered ; and that it would be unreasonable to add substantially to the costs by installing the filtration and treatment which, it was said, would be necessary if the public were permitted to have unrestricted access to the gathering grounds ; they asked why their consumers should pay more for their water merely to provide recreation for others. After inspecting the lake we came to the conclusion that

it could not possibly be regarded as free from risk of pollution in its present condition, and that, if public access were increased, filtration would certainly be desirable. The risk of actual pollution would be, and is, small but not negligible, and for reasons which we have already explained, chlorination without filtration cannot usually be regarded as effective. The amount of protection afforded at present by the moderate extent to which the public avail themselves of their rights of access, except on the roads surrounding the lake, is, in our opinion, entirely outweighed by the risks run by failure to filter.

47. Several undertakers have referred to the additional cost of filtration and we therefore put questions on this point to all the undertakers whose evidence we received and to the British Waterworks Association. The figures given by undertakers showed a cost of purification, including filtration, varying in the case of upland undertakings from $2\frac{1}{2}$ per cent. to 5 per cent. and of lowland undertakings from $2\frac{1}{2}$ per cent. to 7 per cent. of the total cost of the water. The evidence of the British Waterworks Association on this point is contained in Appendix V.

48. Although most of the undertakers from whom we have taken evidence exercise an exceedingly high degree of care over the purity of their water, and the main question has usually been whether some of their restrictions could safely be relaxed, we do not wish it to be supposed that such conditions are universal. We are aware that in many small undertakings the standard of safety is much lower, and that in some cases the imposition of restrictions not at present in force might well be advisable. Small companies and local authorities are often unable to afford adequate technical staff either to inspect their sources or to supervise any purification equipment they may have, and the consequent unsatisfactory conditions prevailing in some places may only be fully remedied if a policy of amalgamations leads to the formation of larger and stronger units of water supply. One minor undertaking which we visited draws its water from several small lakes, over which it attempts no sort of control or supervision whatever. We observed many visitors on the banks of the lakes and the untreated sewage from a small hotel and a popular public house was seen to drain directly into one of them. Water from the lakes was passed into supply without filtration; a chlorination plant had been installed but received very little supervision and was admittedly out of action for months at a time. Conditions such as these served to remind us that laxity can go too far.

49. At this point it is perhaps desirable to comment on a popular misconception to the effect that if insanitary conditions have attended a particular water supply for a number of years without untoward result, the danger can be regarded as negligible, perhaps through the inhabitants developing an immunity. The fact is, of course, that an habitually polluted supply is never an inevitable cause of disease but is always a potential danger. Whether waterborne disease in fact occurs depends upon whether a carrier contributes to the pollution. During the years when no carrier has been present there will have been no disease germs and no question of any immunity. But if sewage has easy access to the water then an epidemic will be probable the moment a carrier appears.

50. After reviewing the evidence then, we feel satisfied that the use of a heavily polluted source in reliance upon treatment alone is not a course to be followed when avoidable. Likewise the use of a supposedly unpolluted surface source in reliance on storage and chlorination without filtration appears to us to fall short of the desirable standard. A reasonably pure source, however, combined with long and secure storage and adequate treatment by both filtration and chlorination appears to be thoroughly satisfactory in practice and to provide, if normally well conducted, sufficient margin for human error or the accidental failure of any single line of defence. These are in fact the conditions

prevailing in the typical lowland impounding systems such as those of Bristol or Leicester. In those cases the reasonably pure source is provided, not by attempting the rigid exclusion of all human and animal life from the gathering ground, but by fencing off the reservoir and in some cases its feeder streams and seeing that adequate steps are taken to deal with human and animal sewage in the area ; small scale pollution of the raw water may arise from time to time but is detected by analysis and traced to its source by inspection. We do not believe that if those upland undertakings which at present attempt rigid control in addition to proper treatment were so far to relax their present restrictions as to approach the conditions in a good lowland impounding system they would either increase the risk to their consumers or require to extend their purification plant. A heavy increase in ploughing might, by greatly adding to the suspended solids in the water, slow down the rate of filtration and thus require an increase in plant, but we consider it most improbable that any increase on this scale would take place on any moorland gathering ground, even though agriculture were entirely unrestricted.

Conclusions

51. The principle then, which we suggest should be followed in the control of gathering grounds, is that the water entering the reservoir should be kept free from gross pollution, that the reservoir itself, and in some cases feeder streams, should be so protected as to prevent any fresh sources of pollution entering it directly and thus short circuiting the purifying effect of storage, and that between the reservoir and the consumer there should be efficient filtration and sterilisation. The adequacy of these lines of defence is, we consider, sufficiently demonstrated by the experience of the Bristol Water Company, the Corby Water Company, Leicester Corporation and many medium sized users of lowland impounded water, who not only provide a pure and wholesome supply in fact but are reasonably satisfied with the conditions under which they do it, and are confident of their ability to maintain their good record without undue anxiety. We do not believe that upland water is any safer than these supplies, and where it is not fully treated it may be less safe. We are not recommending that any degree of gross pollution should be accepted in the water entering upland reservoirs. We do not believe that such relaxations of the rules at present in force at some of them as we are about to suggest would in fact alter the normal state of the raw water, and any temporary failure to observe the safeguards which we consider necessary should be detected by analysis and rectified after inspection, the purity of the water put into supply being safeguarded meanwhile by other lines of defence. Subject to such reasonable safeguards we consider that gathering grounds should be so managed as to make the maximum contribution to the general welfare by providing facilities for healthy recreation and the production of food and timber.

52. By gross pollution, which should in all cases be avoided, we mean the regular discharge of sewage or sewage effluent. We therefore recommend that arrangements should always be made for the sewage from human habitations to be disposed of in such a manner that it cannot pollute the watercourses or the reservoir. This implies not only that permanent houses should have appropriate sanitation, but also that camps and caravans should only be permitted under adequate safeguards. Apart from the discharge from lavatories and latrines, consideration must be given to the risk of casual pollution by human beings in the open. We recognise that it is possible for faeces deposited at some distance from the reservoir to be washed into it by heavy rain, but have come to the conclusion that pollution in this manner is likely to be very slight and can be adequately counteracted by long storage and purification. In this difficult matter of casual pollution we consider that the line should be drawn so as

wholly to exclude direct pollution of the reservoir and its immediate feeder streams, while attempting less rigorous control over indirect pollution. While therefore, we consider that the possibility of casual defecation in the gathering ground away from the reservoir is no cause for exaggerated alarm, we are of opinion that once the water has reached the reservoir and the process of purification by storage has begun, it should be carefully protected from further pollution. We would therefore entirely prohibit bathing and only permit boating, fishing or access to the banks under a system of control by the water undertaker sufficiently rigid to exclude the possibility of abuse. Subject to such limitation as may be necessary for the discouragement of large crowds, we can see no justification, on grounds of water purity, for prohibiting access by walkers, cyclists, or motorists to the remainder of the gathering ground.

53. With regard to camping and caravanning, we have received representations from the Central Committee on Camping Legislation to the effect, inter alia, that such activities are already regulated by local authorities under Sections 268 and 269 of the Public Health Act, 1936, and that the enactment of additional bye-laws by water undertakers is unnecessary and confusing. Section 268, in substance, brings such "temporary dwellings", so far as applicable, within the general sanitary law as applied to ordinary houses, and Section 269 is aimed at semi-permanent camps, not necessarily in gathering grounds or with special reference to water purity. The two sections do not in our opinion provide sufficiently for those special safeguards which we consider to be necessary for the regulation of both permanent and temporary dwellings in gathering grounds, and the further powers of control at present enjoyed by many undertakers are in our opinion often necessary. We consider that so far as water purity is concerned the essential thing is to limit such camping and the parking of caravans as is permitted within gathering grounds to definite approved sites where either proper sewage disposal arrangements exist or where the distance of the reservoir and the nature of the intervening land are such as to preclude risk of pollution. We appreciate that campers and caravanners may be put to some trouble in ascertaining the restrictions in force in different parts of the country, but do not consider that we could safely recommend any general relaxation. It would no doubt somewhat simplify their problem if their own organisations* were to procure the publication of convenient road maps indicating the positions of controlled gathering grounds and permitted sites, much as National Trust properties are at present indicated on many maps on sale to the public.

54. In considering how far, in any particular local circumstances, the general rule against human access to the reservoir itself can safely be relaxed, it must never be forgotten that the essential object is to prevent defecation or urination into it. We were interested to observe the conditions under which dinghy racing is permitted in the Cheddar reservoir of the Bristol Waterworks Company. The privilege is limited to a single association under stringent conditions which include constant attendance and supervision by a duty officer who is able to keep all parts of the reservoir under observation. Lavatories are provided in safe positions and we were satisfied on inspection that, under the strict control exercised by the association the risk of any misconduct was negligible. When not being sailed, the boats are kept out of the water. At a large number of other reservoirs fishing from the banks, or from boats manned by waterworks employees, is permitted on payment of a fee, and we are informed that in general the permit-holders display marked hostility to access by any other persons and in effect perform the functions of unpaid wardens. We think it essential that any access permitted to a reservoir or its banks should always be treated as a valuable

* Central Committee on Camping Legislation, Camping Club of Great Britain and Ireland Caravan Club of Great Britain and Ireland.

privilege and should only be permitted where the undertaker is satisfied, on solid grounds, that the privilege will not be abused. In general, it appears expedient for the privilege to be associated with membership of a responsible club, to whom it is made clear that any misconduct will result in cancellation of its rights. We should be opposed to any general admission of the public at large or the performance of any aquatic event which would be likely to draw crowds to the vicinity of the reservoir. Finally, since it would be quite impossible to control urination by bathers, we are opposed to bathing under any conditions.

55. While such close control of ramblers and other members of the public who make use of the gathering grounds away from the reservoir is neither possible nor desirable, we do feel that there is considerable scope for education in self discipline. We hope that where water undertakers open their land for public enjoyment the associations representing open-air users will respond by making positive efforts to educate their members in good manners and the principles of hygiene.

56. We are aware that pollution is not the only evil that undertakers fear from an increase in public access. They also, and not without reason, fear that a few irresponsible people may start fires, and damage unguarded equipment. But in these anxieties, however well-founded, they are in much the same position as other landowners and should, in our opinion, be subject to whatever policy regarding public access to mountains and moorland may be applicable to landowners in general. We are only concerned with restrictions in the interest of pure water.

57. Subject as before to the protection of the reservoir itself and its immediate feeders, we consider that the greatest freedom should be allowed to all farming activities, and indeed that it should be regarded as the responsibility of those undertakers who are large land-owners not merely to permit but to insist upon the most productive use of their land. Such undertakers should therefore consider the advisability of employing a competent land agent to see that the best use is made of it, consistent with safety. Optimum use of the land and minimum interference with water supply will both, in the majority of upland gathering grounds, dictate farming in large units rather than small holdings, and undertakers might be well advised in some cases to consider the provision of suitable capital equipment. The only serious danger to be apprehended from farming comes from the people engaging in it. Thoroughly satisfactory arrangements should therefore be made for the disposal of their sewage. Cattle and other animals, and their manure, or other fertilisers do not, as has been explained in paragraph 24 above constitute a direct danger to health. They may, however, by contributing *B.coli* to the water, complicate the interpretation of analytical results or, by fostering the growth of algae, complicate filtration, thus occasioning in either case a possible weakening of the defences against human pollution. The aim in dealing with animals should therefore be so to regulate them that, under normal conditions, analysis of the raw water will not give evidence of any substantial pollution. So long as this is done the possibility of occasional animal pollution in exceptional conditions need not be rigidly guarded against. This policy will involve measures to keep animals away from the reservoir itself, and in some cases from feeder streams, and to prevent cowsheds, pigstyes and middens draining into either the reservoir or its feeders ; the use of fertilisers is subject to the same considerations. Exactly what measures are necessary in any individual case can be determined by investigation on the spot, guided by analysis of water in the reservoir.

58. The question of the extent to which feeder streams should be protected is not one to which an unqualified answer can be given. The pollution, close to a reservoir, of a stream entering it near the outlet might well be more serious than

the direct pollution of the upper end of the reservoir itself. On the other hand it would be most burdensome, and in our opinion unnecessary, to fence every upland stream all the way up a mountainside to its source. Between these two extremes the proper measures to take in any particular circumstances can only be left to the judgment of the water undertaker concerned, in pursuance of the general policy of ensuring that, under normal circumstances, no water shall enter the reservoir in such a state and in such a manner as to defeat the purifying effect of storage.

59. All our preceding recommendations relate, of course, to those undertakings where there is long storage in a reservoir followed by efficient filtration and sterilisation. Where only brief storage takes place, or there is no storage or where there is adequate storage but an efficient system of filtration and sterilisation has not yet been installed, protection of the source against the possibility of pollution assumes a greater importance, since there is more chance of the remaining lines of defence failing simultaneously. In such cases, therefore, particular care will be required and we would not encourage the relaxation of any existing restrictions which are likely to assist in the preservation of purity.

60. We have not found it practicable to define with any exactitude the period of storage in a reservoir which can be regarded as an effective line of defence, though it may be stated in general terms that where, under normal conditions, more than a month's supply is stored, and there is no reason to suppose that water from any important feeder stream usually reaches the outlet in less than a fortnight, reasonable protection may be deemed to exist. Fortunately we believe that borderline cases are rare, and that most reservoirs where the rigid protection of the gathering grounds would be a matter of moment to ramblers or agriculture are considerably larger than our suggested minimum. It sometimes happens, however, in times of exceptional drought that even the largest impounding reservoirs are reduced to well below a month's storage. When this occurs, the first line of defence may be regarded as temporarily inoperative and reliance will have to be placed on the others. In such an event it would clearly be impracticable to re-impose restrictions on agriculture but the undertakers might consider, as an emergency measure, the institution of additional chlorination before filtration ("pre-chlorination"), a process which is successfully practised as a regular method by some users of river water.

61. Where long storage exists but both filtration and chlorination are not at present practised we do not, for reasons set out in paragraph 22 above regard the position as entirely satisfactory, and feel that consideration should be given to the necessity for proper purification treatment, not in the interests of ramblers or agriculture, but as a necessary protection to consumers, even where restrictions are in force. Pending such provision the relaxation of restrictions may have to be deferred.

62. It is perhaps unnecessary to point out that where separate reservoirs are maintained exclusively for compensation water, and there is no chance of their being used for domestic water supply, none of the foregoing suggested safeguards are necessary, and there is no public health reason why fishing, bathing, boating and camping should not take place on the largest scale.

63. We are aware that restrictions exist in many cases for the protection of wells and boreholes, but we make no recommendations in respect of these. In most such cases the land subject to restriction is so small in extent as to be a matter of no importance to the other interests. In certain exceptional cases the vagaries of the geological formation may make it desirable to impose more widespread limitations on the use of land, but it is impossible to generalise

about these cases. In general, however, it may be said that any such restrictions are limited to the prevention of changes ; if an underground source were polluted by existing land use it is unlikely that it would ever have been brought into service by a water undertaker.

Afforestation

64. We are also asked to advise on the extent to which afforestation should be permitted in gathering grounds. This question differs widely from those which we have been considering hitherto, since there is no suggestion that afforestation can be dangerous to health, and we have heard of no objections to it in principle. On the other hand, it is bound up with the problem of the most economic use of land owned by water undertakers, and although none of those whose evidence we have received expressed any serious opposition, their actual practice shows some diversity, and it is evident that more thought has been given to the matter by some than by others.

65. Water undertakers have expressed themselves in favour of afforestation for the following reasons :

- (a) for the productive use of land which would otherwise be idle ;
- (b) as a barrier against the public and cattle round the verges of reservoirs and sometimes along feeder streams ;
- (c) as a natural filter for holding up silt and removing pollution from surface run-off, especially in heavy rains ;
- (d) as a " sponge " to even out the flow from varying rainfall ;
- (e) as a wind break.

66. Conifers are more often planted than deciduous trees, mainly owing to the greater ease with which they can be established and the much faster growth and higher returns they give on the capital outlay. Advice is generally sought from the Forestry Commission regarding the best species to plant in any particular locality. The limit of elevation at which trees can be planted in this country varies greatly according to exposure to prevailing winds and the general elevation of the surrounding massif, but is usually about 1,200 to 1,500 feet above mean sea level.

67. There is a shortage of evidence on the direct effect of trees on rainfall but the tendency is more likely to be favourable to an increased rainfall than the reverse. In some conditions condensation of mist may be increased in forests. There is however, no evidence that forests have any effect at all on the amount of precipitation of cyclonic rain of the type that makes up the greatest part of the rainfall of the British Isles, nor, on the scale on which forests are grown in this country, is it likely that they will have any appreciable effect on the distribution of rainfall.

68. The major beneficial effects of forests in gathering grounds purely from a Water Undertakers' point of view are the prevention of erosion with its consequent silting of reservoirs, and the regulation of stream flow by the absorption of water from sudden heavy rain and its comparatively slow release by percolation. Water that would otherwise be lost in a spate is in this way conserved and filtered through the forest soil, ultimately finding its way to the feeder streams in a clarified condition and with more regular flow. The filtering effect is greatest when the soil contains clay particles approaching colloidal fineness. Transpiration losses of water from forest may to some extent counteract the effects of greater infiltration and reduced surface run-off, but on balance the evidence indicates that in mountainous or hilly country any such losses are more than compensated by water gains from better infiltration.

69. We have seen interesting evidence that afforestation up to the edge of scree in the Lake District may create conditions under which humus, moss-growth and even tree regeneration may spread on to scree which were originally unplantable.

70. Criticism of afforestation in individual gathering grounds has come only from the aesthetic angle. The objections raised have been that conifers are sometimes planted in large blocks and straight lines in places where they do not harmonise with the features of the landscape, and that views are obstructed. In the most suitable places for commercial planting, such as flat and low-lying land which is not in areas of scenic beauty, there is little or no objection from the amenity interests. In wild and rugged mountain scenery the objections raised could be largely overcome by careful artistic planning. To this end, not only the Forestry Commission, but also the amenity interests may with advantage be consulted.

71. From a National point of view it is highly desirable that all land which will grow trees and which cannot more advantageously be used for agriculture or other purposes should be afforested, so as to replace to the greatest possible extent imported timber with home grown timber. The total area of such land in the various gathering grounds of Great Britain is considerable and its afforestation would make a notable contribution to the forest resources of the country. Where forestry and agriculture (especially hill-farming) are carried on simultaneously in gathering grounds the allocation of land to each purpose should be so arranged as to make the best use of the land as a whole, care being taken that forest planting does not interfere with the essential requirements of agriculture and vice versa. For instance, when hill sheep farming can be carried on above the upper tree planting limit, ways must be left through the forest for the sheep to descend to lower levels. The possibility should be considered of having wide fire breaks in the forest and, after the plantations are established, of grazing them with sheep so as to keep down the grass and reduce fire risks.

72. We consider that water undertakers should be encouraged to adopt a policy of afforestation in all gathering grounds where soil and climatic conditions are suitable for tree growth and where the land cannot be more economically used for agriculture. The object of such afforestation should be commercial timber production. The Ministry of Agriculture as well as the Forestry Commission should be consulted regarding the best allocation of the land as between agriculture and forestry and the advice of the Forestry Commission should be sought regarding the best species to grow and the methods of raising and managing the plantations. The local amenity interests should also be consulted and plantations should be arranged so as to obtain the best scenic effects consistent with efficient timber production.

Summary of Recommendations

73. Our recommendations for the conduct of the gathering grounds of upland reservoirs where adequate purification processes exist (paragraph 59) may be summarised as follows :—

- (i) arrangements should be made to dispose of the sewage from human habitations, whether permanent or temporary, in a manner which will entirely preclude the possibility of its getting into the reservoir (paragraphs 52 and 53)
- (ii) farmyard manure should be prevented from draining directly into feeder streams or reaching the reservoir (paragraphs 57 and 58) ;

- (iii) the public should be generally excluded from the banks of reservoirs and no bathing should be allowed. Fishing and boating may in some cases be allowed at the undertaker's discretion but only under rigorous control (paragraphs 52 and 54);
restrictions applicable to reservoirs will in some circumstances apply equally to feeder streams (paragraphs 57 and 58);
- (iv) subject to the above safeguards the land should be put to the utmost agricultural use (we are satisfied that many gathering grounds could be put to greater agricultural production than at present) (paragraph 57);
- (v) land which is incapable of agricultural use should if possible be afforested, but with due regard to amenity and the requirements of adjacent agriculture (paragraph 72);
- (vi) subject to the foregoing recommendations there is no reason to exclude the public from gathering grounds as such (paragraph 52).

Acknowledgements

74. We wish to express our thanks to the assessors appointed by the interested Government Departments for their helpful assistance and suggestions. They took part in our meetings and visits and we were glad to have the benefit of their experience. Finally we desire to express our grateful appreciation of the experience, tact and organising ability shown by our Secretary, Mr. W. A. Fuller, D.S.C., of the Ministry of Health, who has considerably lightened our task, not only with regard to our meetings and our visits to gathering grounds but also in the drafting of our report.

ARTHUR P. HENEAGE (*Chairman*)
HENRY BERRY
G. C. BENNETT EVANS
WYNNE CEMLYN-JONES
LEONARD K. ELMHIRST
F. HIBBERT
E. F. W. MACKENZIE
J. N. McCLEAN
PHILIP PORTEOUS
REA
N. F. S. WINTER

W. A. FULLER,
Secretary

APPENDIX I

A

Written evidence has been received from the following bodies :—

- Birmingham Corporation.
- Bradford Corporation.
- Bristol Waterworks Company.
- Burnley Corporation.
- Cardiff Corporation.
- Corby (Northants.) and District Water Company.
- Derwent Valley Water Board.
- Fylde Water Board.
- Great Yarmouth Waterworks Company.
- Halifax Corporation.
- Hartlepool Gas and Water Company.
- Hastings Corporation.
- Hereford Corporation.
- Irwell Valley Water Board.
- Leeds Corporation.
- Leicester Corporation.
- Liverpool Corporation.
- Manchester Corporation.
- Metropolitan Water Board.
- Milford Haven U.D.C.
- Newcastle and Gateshead Water Company.
- Northallerton U.D.C.
- North East Derbyshire Joint Water Committee.
- Norwich Corporation.
- Oxford Corporation.
- Plymouth Corporation.
- Sheffield Corporation.
- South Essex Waterworks Company.
- South-West Suburban Water Company.
- Swansea Corporation.
- Thirsk District Water Company.
- Torquay Corporation.
- Wakefield Corporation.
- Wigan Corporation.
- Wrexham and East Denbighshire Water Company.
- Worcester Corporation.
- Workington Corporation.
- British Waterworks Association.
- Fresh Water Biological Association.
- Institution of Water Engineers.
- Medical Research Council.
- Society of Medical Officers of Health.
- Thames Conservancy.
- Automobile Association.
- Association of Fishery Boards.
- Association of Municipal Corporations.
- Camping Club of Great Britain and Ireland.
- Caravan Club of Great Britain and Ireland.
- Catchment Boards Association.
- Central Committee on Camping Legislation.
- Central Landowners Association.

APPENDIX I—*continued*

Commons Open Spaces and Footpaths Preservation Society.

Council for the Preservation of Rural England.

Council for the Preservation of Rural Wales.

Friends of the Lake District.

Joint Committee for the Peak District National Park.

National Farmers Union.

Ramblers Association.

Standing Committee on National Parks of the Councils for the Preservation of Rural England and Wales.

Youth Hostels Association.

and from

Sir George Stapledon.

B

Oral evidence was given at the Sub-Committee's formal meetings in London by the following gentlemen :—

On behalf of the British Waterworks Association, by

Mr. Leonard Millis, B.Sc., Ecom.

On behalf of the Bristol Waterworks Company, by

Mr. A. Paterson, M.C., M.I.C.E.

On behalf of the Councils for the Preservation of Rural England and Wales, and their Standing Committee on National Parks, the Commons, Open Spaces and Footpaths Preservation Society, the Friends of the Lake District and the Caravan Club, by

The Rev. H. H. Symonds and

Mr. T. Stephenson.

On behalf of Birmingham Corporation, by

Mr. A. E. Fordham, A.I.M.T.A.

Mr. C. A. Risbridger, B.Sc., M.I.C.E.

On behalf of Burnley Corporation, by

Mr. J. Shepherd, M.I.C.E., A.M.I.Mech.E.

On behalf of Swansea Corporation, by

Mr. T. Price, M.I.C.E., M.I.W.E.

On behalf of the Great Yarmouth Waterworks Company, by

Mr. S. A. I. Walton, O.B.E., A.M.I.C.E., A.M.I.W.E.

On behalf of Sheffield Corporation, by

Mr. J. Noel Wood, M.C., M.I.C.E.

On behalf of Manchester Corporation, by

Mr. Alan Atkinson, M.Eng., M.I.C.E., M.I.W.E.

On behalf of the Central Committee on Camping Legislation, by

Mr. T. T. Blythe and

Mr. L. M. Wulko.

On behalf of the Ramblers Association, by

Mr. P. Barnes and

Dr. F. S. H. Head.

On behalf of the Society of Medical Officers of Health, by

Sir William Savage, B.Sc., M.D.

APPENDIX II

Summary of Evidence received from Water Undertakers having large Impounding Reservoirs

A. UPLAND

Undertaking	Total Area of Gathering Ground in acres	Area Owned	Access Policy	Agricultural Policy (Organic manures prohibited on controlled land unless the contrary is stated)	Treatment of water in addition to chlorination	Remarks
1. Birmingham Corporation (Elan system)	45,440	45,440	Free access away from reservoir provided by statute.	Sheep permitted, very little other farming considered practicable but a few farms exist.	Rough filtration followed by either slow sand or rapid sand gravitational filtration.	No bye-laws.
2. Bradford Corporation	27,869	8,479	" Public should not have free access "	One sheep allowed per two acres. Very limited ploughing allowed well away from reservoirs. Cattle and poultry objected to.	Either slow sand or pressure filters, the latter with a coagulant.	On the 8,479 acres owned by the Corporation all human habitations have been removed.
3. Burnley Corporation	2,812	2,422	Total Prohibition.	Total Prohibition.	In the case of two out of three sources, mechanical filtration.	
4. Cardiff Corporation	10,400	3,065	Unrestricted over commons which form greater part of gathering ground. Fishing in reservoir by permit. Latrines erected for fishermen.	Sheep allowed, but not cattle. Ploughing limited in extent.	Filtration.	Farmhouse sewerage provided by undertakers.
5. Derwent Valley Water Board	38,500	4,000	Unrestricted except on agricultural or arborised land and at the water's edge. Camping not allowed near reservoirs or streams.	Unrestricted except at water's edge.	Filtration.	Farmhouse sewerage attended to. Statutory zone of Protection restricted to Edale Valley.
6. Fylde Water Board	10,193	12,342	Prohibited except that sporting rights away from the reservoir are let. No fishing.	Sheep kept away from reservoir. Cattle kept away from reservoir and feeders. Cultivation severely limited.	Pressure filters with a coagulant.	Pollution experienced during military occupation as a "battle area".
7. Halifax Corporation	9,314	4,152	Public admitted on foot-paths only.	Sheep allowed but not cattle or ploughing.	Mechanical filtration.	
8. Hartlepool Gas and Water Company	5,449	271	" Should where possible be prohibited "	Cattle kept from streams. Chemical fertilizers restricted.	None.	Supply water for trade purposes only.
9. Irwell Valley Water Board	5,379	5,379	" There is a definite need to restrict access "	Total prohibition preferred but a few sheep introduced under pressure during the war.	A small proportion is filtered.	All farms demolished.
10. Leeds Corporation	42,212	12,954	Limited to Rights of Way including some newly dedicated by the corporation. Fishing allowed under regulation. No camping.	Sheep and Cattle allowed but kept from streams by fencing or afforestation. Ploughing allowed over a limited area. Pigs prohibited.	Slow sand filtration.	Sewerage attended to by undertakers.

APPENDIX II—*continued*

Undertaking	Total Area of Gathering Ground in acres	Area Owned	Access Policy	Agricultural Policy (Organic manures prohibited on controlled land unless the contrary is stated)	Treatment of water in addition to chlorination	Remarks
11. Liverpool (Vyrnwy system) Wales	23,290	22,764	Lake surrounded by a road; public not interfered with in practice.	Extensive sheep grazing; limited numbers of cattle; suitable areas cultivated by undertakers themselves.	Slow sand filtration.	Complaints of fires started by visitors.
(Rivington system) Lancashire	9,710	9,607	Virtually unrestricted; crossed by many roads and footpaths; much frequented on holidays.	Generally unrestricted except for fencing streams; many farms.		
12. Manchester (Lakes)	34,810	Guaranteed by statute.	Prohibited, except sheep.		Opposed in principle to public access.
(Longendale)	19,300	Limited to a few paths.			From one lake, mechanical straining, from the other, nothing.
13. Milford Haven U.D.C.	2,358	Unrestricted except at waters edge.	Generally unrestricted but cattle kept from water's edge and streams.	Pressure filters with coagulant.	Filtration
14. Newcastle and Gateshead Water Company (Cattcleugh)	9,848	6,600	Unrestricted	Unrestricted	Slow sand or mechanical filters.	The Company also has low-land and river sources. Farm sewerage inspected and assisted.
15. Northallerton U.D.C.	1,250	17	Prohibited on land owned.	Prohibited, except sheep.	None.	Bye-laws cover the whole gathering ground and govern sanitary arrangements.
16. North East Derbyshire Joint Water Committee	3,060	1,964	Only by permit and limited to paths. No picnics.	Unrestricted.	Part mechanically filtered with coagulant, part not.	
17. Plymouth Corporation	10,078	5,360	Unrestricted except at water's edge. No dwelling houses or camps allowed.	None at present but filtration is planned.	Farm sewerage controlled.
18. Sheffield Corporation	...	32,763	8,049	Public encouraged to keep to footpaths of which there are a considerable number. Co-operation sought with ramblers organisations.	Virtually unrestricted except at water's edge. 27 farms owned.	Generally favourable to public access.
19. Swansea Corporation	5,156	191	Opposed to access but unable to prevent it.	Slow sand or pressure filtration.	Some re-chlorination; no filtration.
20. Thirsk District Water Company	...	250	None	" There is certainly need of restriction in public access", for anything but sheep.	None.	Bye-laws are in force.

APPENDIX II—*continued*

Undertaking	Total Area of Gathering Ground in acres	Area Owned	Access Policy	Agricultural Policy (Organic manures prohibited on controlled land unless the contrary is stated)	Treatment of water in addition to chlorination	Remarks
21. Torquay Corporation	4,814	2,440	Prohibited exceptayers and fishermen with permits.	Sheep kept away from water's edge and streams. Cattle not allowed. Ploughing allowed in limited area.	Candy pressure sand filters.	—
22. Wakefield Corporation	6,108	7,514	Limited to paths.	Unspecified restrictions in tenancy agreements. Considered generally unsuitable except for sheep.	Slow sand or pressure filters.	—
23. Wrexham and East Denbighshire Water Company.	c3,100	c140	Generally opposed.	Cattle prohibited. Company intend to prohibit all forms of agriculture except sheep on their own land.	Filtration.	—
24. Workington Corporation	16,600	One small farm.	Unrestricted.	Unrestricted.	Coarse strainer.	—
B. LOWLAND						
25. Bristol Waterworks Company ..	14,170	1,500	Reservoirs and feeders fenced. Fishing by permit holders. Controlled boat sailing. (See paragraph 52).	Virtually unrestricted except at water's edge and along feeders. Bye-laws regulate farmyard sanitation.	Slow sand filtration.	Village and farm sewerage arranged and inspected by the company. Bye-laws cover whole area. Algae no trouble.
26. Corby (Northants.) and District Water Company.	15,000	750	Unrestricted except within fence about 500 yards from water's edge.	Unrestricted except within fence, where cultivation is allowed subject to regulations about fertilizers.	Filtration.	No bye-laws. Algae a serious nuisance.
27. Hastings Corporation	3,595	1,880	No restrictions, but gathering grounds are well wooded and very little access takes place.	Bye-laws restrain sheep, cattle and cultivation in vicinity of feeders and regulate farmyard sanitation.	Sedimentation and mechanical filtration.	—
28. Leicester Corporation	10,760	685	Unrestricted away from the reservoirs.	Measures to prevent milk-waste and waste from piggeries gaining access to the reservoirs. No restrictions on fertilizers.	Slow sand filtration.	No bye-laws. Village sewerage arranged by the undertakers. Algae a serious nuisance. The Corporation also obtains a large supply from the Derwent Valley Water Board.
29. Wigan Corporation	1,156	21	Unrestricted.	Control of farmyard sanitation attempted.	Filtration.	No bye-laws. "The principle of ownership of the catchment area has now been accepted".

APPENDIX III

Birmingham Clauses

The following clauses from the Birmingham Corporation Water Act, 1892, are commonly known as "The Birmingham Clauses" and have been copied in other local Acts.

" 53. The public shall be entitled to a privilege at all times of enjoying air, exercise and recreation on such parts of any common or inclosed land acquired by the Corporation in the parishes of Yspytty-Ystwyth in the County of Cardigan, Llanwrthwl in the County of Brecknock and Llansantffraid-cwmdeuddwr in the County of Radnor and the parish of Llangurig in the county of Montgomery (and whether any common or commonable rights in or over such lands shall have been acquired or extinguished under the provisions of this Act or not) as shall not be included within the limits of deviation for works mentioned in this Act subject nevertheless to the provisions of and to the bye-laws authorised by this Act.

" 54. All rights of fishing in the Rivers Elan and Claerwen and their tributaries flowing through the manor of Grange and manor of Builth above the upper end of the upper reservoirs and in the lakes adjacent thereto hitherto enjoyed by the inhabitants of the district and the town of Rhayader and all rights of turbary and of cutting fern and rushes over such commonable land shall be preserved to the said inhabitants as heretofore and without interruption by the Corporation subject nevertheless to the bye-laws authorised by this Act."

APPENDIX IV

Costs of Purification Treatment

Figures supplied by the British Waterworks Association

Note.—Where figures are given for more than one kind of treatment by the same undertaking this indicates that different sources are differently treated.

Undertaking	Total quantity of purified water supplied per annum in millions of gallons	Total cost per 1,000 gallons in pence	Cost of treatment in pence per 1,000 gallons, including capital charges.		
			Simple chlorination	Chlorination plus slow sand filtration	Chlorination plus rapid filtration with coagulation (or other method as indicated).
Ashton-under-Lyne, Stalybridge and Dukinfield (District) Joint Committee.	1,640	15.4	—	—	1.125*
Bexhill Corporation	406	8.894	1.623†	1.167	1.167
Blackburn Corporation	1,712	16.70	.169	—	1.167
Bolton Corporation	3,622	11.888	.07	—	1.167
Brighton Corporation	675	11.1889	.008†	—	.539
Cardiff Corporation	3,339	16.41	.12	—	.213*
Colne Corporation	223	18.15	—	—	1.26
Doncaster Corporation	219	19.82	—	—	.752
Ebbw Vale U.D.C.	640	7.3	—	—	—
Edinburgh Corporation	10,283	6.418	Not available	.574	1.1314

* Ozone.

† Machinery is installed at all pumping stations for emergency use only.

‡ Includes wages.

APPENDIX IV—*continued*

Undertaking	Total quantity of purified water supplied per annum in millions of gallons	Total cost per 1,000 gallons in pence	Cost of treatment in pence per 1,000 gallons, including capital charges.
Edinburgh Corporation	10,383	3-418	
Edin. and G.D.C.	270	5-3	
Leeds Corporation	316	10-33	
London Corporation	10,312	18-12	Chlorination plus rapid filtration with coagulation (or other method as indicated).
Cardiff Corporation	19-30	8-384	Chlorination plus slow sand filtration
Birmingham Corporation	1,002	1-610	Simple chlorination
Leeds Corporation	1,002	1-610	
Fylde Water Board	4,548	14-17	
Glasgow Corporation	29,380	4-4619	
Harrogate Corporation	945	24-00	Unable to analyse costs
Ipswich Corporation	1,340	—	
Lanarkshire Co. Council	1,340	—	
Leeds Corporation	4,252	—	
Liverpool Corporation	8,043	—	
Manchester Corporation	19,783	—	
Manchester Corporation	27,300	7-632	
Newcastle and Gateshead Water Company	9,448	—	
Rickmansworth and Uxbridge Valley Water Company	3,797	—	
Stockport Corporation	3,576	—	
Swindon Corporation	1,239	—	
		209	Cost of treatment plus capital charges

* Break point chlorination plus rapid filtration with coagulation. See *British Association's Proceedings*.

Cost of treatment plus capital charges

Cost of treatment plus capital charges

APPENDIX IV

The Water Act 1945

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Relating to Water Supply

1st October, 1945 to

13th August, 1947

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